Open Journal of Pediatrics, 2014, 4, 107-114
Published Online March 2014 in SciRes. http://www.scirp.org/journal/ojped
http://dx.doi.org/10.4236/ojped.2014.41015

Vitamin and Mineral Levels of Newborns in Van Basin and Their Relation to Maternal Vitamin and Mineral Status

H. Sağmanligil Özdemir[1], F. Karadas[2], I. Yörük[3], G. Oto[1], E. Erdemoğlu[4], A. Yesilova[2]

[1]Department of Pharmacy, Faculty of Medicine, Yüzüncü Yil University, Van, Turkey
[2]Department of Animal Science, Faculty of Agriculture, Yüzüncü Yil University, Van, Turkey
[3]Department of Chemistry, Faculty of Arts and Science, Yüzüncü Yil University, Van, Turkey
[4]Department of Obstetrics and Gynecology, Faculty of Medicine, Süleyman Demirel University, Isparta, Turkey
Email: fkaradas@yyu.edu.tr

Received 24 January 2014; revised 20 February 2014; accepted 28 February 2014

Abstract

This study was designed to evaluate the correlation between vitamin and mineral levels of mothers and their neonates. Vitamin, mineral and biochemical parameters were assessed from samples of maternal blood, hair and milk and neonatal hair, umbilical cord blood and meconium. Neonatal retinol plasma levels as well as neonatal alpha- and gamma-tocopherol levels were significantly lower ($P < 0.01$) than maternal levels. Neonatal zinc and iron levels were significantly higher ($P < 0.01$ and $P < 0.05$, respectively) and neonatal copper and magnesium levels significantly lower ($P < 0.01$ and $P < 0.05$, respectively) than maternal levels. Neonatal hair potassium ($P < 0.05$), calcium ($P < 0.01$), iron ($P < 0.01$), copper ($P < 0.01$), magnesium ($P < 0.01$), manganese ($P < 0.01$) and zinc ($P < 0.01$) levels were found significantly lower than maternal hair levels, and neonatal hair cobalt levels were significantly higher than maternal hair levels ($P < 0.01$). Neonatal plasma glucose and total protein levels were significantly lower than maternal levels ($P < 0.01$), whereas neonatal total, direct and indirect bilirubin, AST, albumin, phosphorous, sodium, potassium and calcium levels were significantly higher than maternal levels ($P < 0.01$). Most of the results obtained from the study data were in line with previous literature and indicated that maternal and neonatal health in the Van Basin is not at risk in terms of nutritional status.

Keywords

Mother; Neonate; Mineral; Vitamin; Biochemical Parameters

How to cite this paper: Sağmanligil Özdemir, H., *et al.* (2014) Vitamin and Mineral Levels of Newborns in Van Basin and Their Relation to Maternal Vitamin and Mineral Status. *Open Journal of Pediatrics*, **4**, 107-114.
http://dx.doi.org/10.4236/ojped.2014.41015

1. Introduction

Vitamins, minerals and trace elements are essential micronutrients for growth and maintenance of healthy tissues. Blood is a medium for a transport of trace elements and it can be easily collected. Therefore, whole blood, plasma and serum are generally convenient samples for the determination of the trace element status of a person. However, trace elements in umbilical cord sera of newborns have different concentrations compared to the sera of infants and of children or of adults, and may reflect trace element status of the mother [1]. Human milk is considered to be an optimal source of nutrition for the infant. For exclusively breast-fed infants, milk must be nutritionally adequate and provide the trace metals needed for normal growth and development [2]. Although trace mineral concentration is relatively low in human milk and blood, trace minerals play a critical role in many physiological processes [3]. Sufficient evidence exists, that suboptimal intake of essential trace elements retards growth, causes anemia, influences the immune system and impairs organ functions [4]. In some studies, it has been shown that administration of vitamin E can reduce the severity of diseases with a high production of oxygen free radicals [5]. Vitamin A, on the other hand, plays an important role in cellular function, development and maintenance of normal visual acuity [6].

Nutritional elements and toxic substances are transported from mother to fetus via blood circulation. The levels of trace elements and toxic metals in fetal blood may not reflect the degree of fetal exposure to toxic metals or deficiency of trace elements. Many substances processed by the fetus accumulate in the fetal intestine, thus meconium analyses may also be used to assess levels of fetal exposure to toxic metals and mineral content [7].

In the present study, the relationships between maternal and neonatal mineral and vitamin concentrations in different biological material are evaluated.

2. Material and Methods

Forty-eight pairs of mothers and their newborns (delivered at term ≥37 completed weeks gestation) were recruited at the Van Maternity and Children's Hospital in Van after all mothers had signed informed consent released in April-May 2010. The study was in accordance with ethical standards and was approved by Ethics Committee at the Yüzüncü Yil University Research Hospital.

2.1. Analyses of Minerals

Maternal blood, milk and hair, umbilical cord blood, neonatal hair and meconium were obtained from 48 mother-infant pairs who participated in this study. Specimens were frozen immediately and kept at −20˚C until analyses.

2.2. Measurement of Plasma Mineral Levels

Plasma was obtained by immediate centrifugation of blood for 10 minutes at 3000 rpm. The samples were transferred to 5 ml tubes and diluted with 1% Triton × 100 solution.

Mineral levels were determined using Flame Atomic Absorption [8].

2.3. Measurement of Hair Mineral Levels

Hair samples were washed four times using 1% Triton ×100 solution, rinsed two times with double distilled water and dried in oven to solid mass (2 hours at 100˚C). 200 mg samples were transferred to 10 ml tubes and mineralized with a mixture of nitric and perchloric acid. Tubes with hair samples were held in a water-bath at 60˚C for 6 - 7 hours. Dissolved hair samples were transferred to 10 ml volumetric flasks, and diluted until 10 ml with 1% Triton × 100 solution. Mineral levels were determined using Flame Atomic Absorption [9].

2.4. Measurement of Minerals in Meconium

The meconium samples were collected from diapers with a wooden scoop and kept frozen at −20˚C until testing was done. For analysis all specimens were dried. Samples weighing approximately 0.10 - 0.30 g were transferred to test tubes and treated with 2 ml concentrated nitric acid with occasional shaking until dissolved was completed. The dissolved solution was diluted and then filtered to remove insoluble material. The samples were analyzed by atomic absorption spectrophotometer [10].

2.5. Biochemical Blood Analysis

All biochemical blood parameters were assayed by routine Modular Analyzer (The Roche Modular PP Auto Analyser, Roche Diagnostics, Mannheim, Germany) using Roche kits.

2.6. Statistic

All Statistical calculations were performed in SAS. The average paired absolute differences were calculated between a mother and her newborn in the following traits: maternal and neonatal plasma vitamin, minerals and biochemical parameters; maternal and neonatal hair mineral levels by paired t test. Linear regressions in $\log_{10}$ transformed retinol, α and γ-tocopherol concentrations between a mothers and her new born in the flowing trait: maternal plasma and neonatal plasma, maternal milk and neonatal plasma. The observed averaged paired absolute differences and regression slopes were compared with test distributions from 1000 re-sampled bootstrap averages and slopes where the numbers of samples were maintained, but the relationship between a mother and her newborn was randomized among samples. Pearson correlation coefficients for meconium mineral levels were tested. All descriptive statistics are presented as mean (x) ± standard error (SE).

3. Results

This study was conducted on a group of healthy women who gave birth to healthy neonates through normal vaginal delivery at the Van Maternity and Child Diseases Hospital in the city of Van in eastern Turkey.

A significant correlation was found between neonatal length and weight ($r = 0.88$; $P < 0.0001$). Age of neonates at delivery was similar (mean age: 40.78 ± 1.21 weeks); the mean weight of neonates was 3.11 ± 0.43 kg. 62.5% of the neonates were girls and 37.5% were boys. The mean age of mothers was 26.76 ± 6.78. Plasma vitamin levels of mothers and their newborns are given in **Table 1**. Neonatal retinol, α-tocopherol and γ-tocopherol plasma concentrations were significantly lower than maternal values ($P < 0.05$). Milk retinol, α-tocopherol and γ-tocopherol concentration has been given in **Table 2**.

As **Table 3** shows, no significant difference were found between maternal and neonatal potassium and manganese levels ($P > 0.05$); however, neonatal zinc and iron values were notably higher than maternal values (P <

Table 1. Maternal and neonatal plasma Vitamin A and Vitamin E levels (µl/ml).

Vitamins	N	Maternal $\bar{x}$ ± SE	N	Neonate $\bar{x}$ ± SE	P
Retinol	47	0.20 ± 0.020	48	0.11± 0.002	P < 0.01
α-tocopherol	47	13.34 ± 0.621	48	1.88 ± 0.141	P < 0.01
γ-tocopherol	47	1.24 ± 0.120	48	0.05 ± 0.012	P < 0.01

Table 2. Maternal milk vitamin levels (µl/ml).

Vitamin	N	Maternal $\bar{x}$ ± SE
Retinol	10	0.01 ± 0.001
α-tocopherol	10	2.53 ± 1.201
γ-tocopherol	10	0.39 ± 0.212

Table 3. Maternal and neonatal plasma mineral levels (mg/l).

Mineral	N	Maternal $\bar{x}$ ± SE	N	Neonate $\bar{x}$ ± SE	P
K	18	164.37 ± 1.210	20	165.59 ± 1.040	P > 0.05
Fe	18	1.72 ± 0.261	20	2.38 ± 0.101	P < 0.05
Cu	18	2.25 ± 0.120	20	0.32 ± 0.030	P < 0.01
Mg	18	20.75 ± 0.830	20	18.02 ± 0.920	P < 0.05
Zn	18	0.94 ± 0.030	20	1.22 ± 0.040	P < 0.01
Mn	18	0.03 ± 0.001	19	0.03 ± 0.003	P > 0.05

0.01 and P < 0.05, respectively) whereas neonatal copper and magnesium levels were significantly lower than maternal levels (P < 0.01 and P < 0.05, respectively).

Maternal and neonatal hair mineral levels are given in **Table 4**. While neonatal hair potassium (P < 0.05), calcium (P < 0.01), iron (P < 0.01), copper (P < 0.01), magnesium (P < 0.01), manganese (P < 0.01) and zinc (P < 0.01) levels were significantly lower than maternal hair levels, the neonatal hair cobalt level was significantly higher than the maternal hair level (P < 0.01). The difference between maternal and neonatal hair sodium levels was not significantly different (P > 0.05). Neonate meconium mineral content is given in **Table 5**.

Blood samples from mothers and newborns were analyzed for all routine biochemical parameters using an auto-analyzer. Results are given in **Table 6**.

There were no notable differences between maternal and neonatal urea and creatinine levels (P > 0.01). However, maternal glucose and total protein concentrations were significantly higher than those of neonates (P < 0.01), whereas neonatal total bilirubin, direct and indirect bilirubin, AST, albumin, phosphorous, sodium, potassium and calcium content were significantly higher than those of mothers (P < 0.01).

4. Discussion

There are a limited number of publications related to the status of vitamins A and E, and other biochemistry parameters in umbilical cord blood of neonates and their mothers and mineral levels in meconium from babies and mineral levels from hair of both babies and their mothers. Our results are the first to report; (i) maternal plasma and infant umbilical cord blood biochemical parameters, including vitamins A and E concentrations, (ii) hair mineral levels of both mothers and their neonates, and (iii) mineral concentrations in the meconium, from mothers and their neonates living in the Van Basin.

Data in **Table 1** show neonatal retinol, alpha-tocopherol and gamma-tocopherol plasma concentration. Retinol plasma concentration of neonates was 0.1057 µg/ml (10.57 µg/100ml) and this is very similar to results from other studies Tolba *et al.* [11] that reported preterm levels of retinol as 13.8 µg/100ml. However, as has also

Table 4. Maternal and neonatal hair mineral levels (mg/l).

Mineral	N	Maternal $\bar{x}$ ± SE	N	Neonate $\bar{x}$ ± SE	P
K	20	4.24 ± 0.330	19	3.33 ± 0.334	P < 0.05
Ca	19	82.7 ± 9.144	18	18.88 ± 0.884	P < 0.01
Na	18	21.36 ± 6.556	18	14.38 ± 1.870	P > 0.05
Fe	20	0.69 ± 0.085	19	0.34 ± 0.030	P < 0.01
Cu	20	0.25 ± 0.020	18	0.03 ± 0.002	P < 0.01
Mg	20	6.03 ± 0.090	19	3.21± 0.165	P < 0.01
Co	14	0.004 ± 0.005	13	0.05 ± 0.020	P < 0.01
Mn	20	0.06 ± 0.010	18	0.01 ± 0.003	P < 0.01
Zn	20	4.07 ± 0.363	18	0.80 ± 0.122	P < 0.01

Table 5. Neonate meconium mineral content (mg/l).

Minerals	N	Neonate $\bar{x}$ ± SE
K	25	96.66 ± 14.89
Ca	25	59.14 ±7.53
Na	25	89.00 ± 13.22
Fe	25	61.56 ± 10.43
Cu	25	41.76 ±7.26
Mg	25	59.22 ± 9.64
Co	16	1.01 ±0.14
Mn	25	21.50 ±5.27
Zn	25	186.21 ±24.56

Table 6. Maternal and neonatal plasma biochemical parameters.

Biochemical parameters	N	Maternal $\bar{x}$ ± SE	N	Neonate $\bar{x}$ ± SE	P	Normal values
Glucose (mg/dl)	28	129.68 ± 7.84	28	79.68 ± 4.85	P < 0.01	75 - 115
Urea (mg/dl)	28	20.07 ± 1.36	28	20.57 ± 1.36	P > 0.05	5 - 25
Creatinine (mg/dl)	28	0.56 ± 0.02	28	0.60 ± 0.02	P > 0.05	0.6 - 1.2
Total Bilirubin (mg/dl)	28	0.55 ± 0.09	28	2.10 ± 0.50	P < 0.01	<1.2
Direct Bilirubin (mg/dl)	28	0.10 ±0.01	28	0.50 ±0.02	P < 0.01	0.1 - 0.3
Indirect Bilirubin (mg/dl)	28	0.45 ± 0.03	28	1.60 ±0.08	P < 0.01	0.2 - 0.7
AST (U/l)	28	22.83 ± 2.40	28	41.25 ± 3.37	P < 0.01	0 - 35
ALT (U/l)	28	16.21±1.35	28	16.55±2.42	p>0.01	0 - 35
Total Protein (g/dl)	28	6.90 ±0.09	28	5.98 ± 0.14	P < 0.01	6.0 - 8.7
Albumin (g/dl)	28	3.45 ± 0.06	28	3.75 ± 0.08	P < 0.01	3.5 - 5.5
Phosphor	28	3.45 ± 0.09	28	5.53 ± 0.11	P < 0.01	3 - 4.5
Sodium (mmol/l)	28	136.89 ± 0.30	28	138.43 ±0.27	P < 0.01	135 - 148
Potassium	28	4.13 ±0.08	28	5.50 ± 0.14	P < 0.01	3.5 - 5.5
Calcium (mg/dl)	28	9.13 ± 0.08	28	9.86 ± 0.86	P < 0.01	8.5 - 10.5
ALP2 (U/l)	28	205.89±15.27	28	217.85±33.66	p>0.01	30 - 120
LDH (U/l)	28	253.68±19.97	28	432.29±24.47	P < 0.01	<480

been reported in the previous studies, this level is lower than acceptable norms of 20 µg/100ml O'Neal *et al.* 1977. Our results are parallel to the results of Ibrahim *et al.* 1991 and Hussein *et al.* 1988 Tolba *et al.* [11]. It has been reported that a level of plasma vitamin A below 10 µg/100ml is considered to be deficient, while a plasma vitamin A levels equal to or in excess of 20 µg/100ml is generally considered to be adequate Tolba *et al.* [11].

Retinol plasma concentration of neonates was also significantly lower than concentrations in maternal plasma 20.38 µg/100ml ($p < 0.05$). These findings are in accordance with other reports [12]. Our findings clearly showed that vitamin E levels in umbilical cord blood are lower than in maternal blood. This finding is also in accord with previous reports. In most publications a positive correlation between cord and maternal serum vitamin E level has been reported [7] however in the present study, the correlation between maternal plasma and neonatal plasma was not detected (**Table 7**). Nevertheless, there was a close relationship between neonatal plasma and maternal milk (**Table 7**). It is obvious that neonatal vitamin E concentration is dependent on maternal milk vitamin E levels [7].

Linear regressions in Vitamin E concentrations between a maternal trait and a child's trait were significantly positive for comparisons between maternal breast milk and child cord blood plasma (retinol; **Table 7**), and between maternal breast milk and child blood plasma (gamma-tocopherol; **Table 7**). However, all linear relationships between maternal blood plasma and child cord blood plasma (retinol, α-tocopherol, and γ-tocopherol), and between maternal breast milk and child blood plasma (alpha-tocopherol) were not significantly different from zero (**Table 7**).

It has been reported that the average retinol concentration of human milk is 30 to 60 µg/dl [13]. This agrees well with earlier reports (Lesher *et al*, 1945; Kon and Mawson, 1950; Rodriguez and Irwin, 1972; Wallingford and Underwood, 1986 [14]). However, our results, 0.013 µg/ml (1.3 µg/dl), is not coherent with those publications. In our study, we found a correlation between neonatal serum and milk retinol concentration. There was no correlation between maternal plasma and milk retinol concentration (**Table 7**). This result is in accordance with Villard and Bates's study [15] in which no correlation over the lactation period was seen.

Since a deficiency or excess of various minerals and trace elements (iron, zinc and copper) may associate with many health complications during pregnancy, we also investigated mineral concentration of neonatal-maternal plasma and hair. Zinc and iron concentrations in neonatal serum were significantly higher than maternal concentrations and these results are in close accordance with results reported in the literature [16]. Maternal zinc levels were found to be lower than in neonates, however it is still not at deficient levels since this has been reported as 69.9 µg/dl by Rathi *et al.*, 1999. It has already been reported that zinc transporters, such as ZnT, that are localized in the placenta, may play an important role in accelerating zinc uptake from maternal blood to the developing fetus [16]. However, no significant correlation between maternal and umbilical cord plasma mineral levels such as Zn, Mg, Mn, Fe, Ca, Na and K was found. The level of minerals of both maternal and neonatal plasma are in agreement with the previous reports for Zn, Cu, and Fe [16] and for Mn [17]. Our results are very close to the acceptable ranges of Cu 1.18 - 3.2 mg/L and Zn 0.7 - 1.5 mg/L for maternal plasma, as reported in AMAP [18] and 2.09 - 2.07 mg/L as reported in Butler Walker *et al*. [19].

Similar results have been obtained from maternal hair and neonatal hair mineral concentrations. However, zinc concentrations in neonatal hair were significantly lower than in maternal hair and this result was not in an agreement with previous studies reported by Rathi *et al*. [20]. Another interesting result was a significan correlation in K concentration between maternal and neonatal hair (r = 0.593; P = 0.007). Compared to K, the other minerals investigated in this study Zn, Mn, Co, Mg, Cu, Ca, Na were not correlated between maternal and neonates.

We have also reported meconium mineral levels (**Table 5**). Our Zn, Cu and Fe concentrations in meconium samples were lower than those reported by Haram-Mourabet [21] and Türker *et al*. [22] but higher than report of Gonzales de Dios [23].

K was significantly correlated with Mg, Zn and Fe in the meconium respectively ($p < 0.001$). Similar correlations were found between Mg, Zn and Cu. In addition, Zn was positively correlated with both Fe and Cu (**Table 8**). These results are compatible with previous results [22].

We investigated the biochemical parameters of plasma maternal-neonatal pairs during birth. All the results in this study indicated that maternal and neonatal biochemical parameters were in range of normal values (**Table 6**)

Table 7. Linear regressions among mothers and children for 29 different human pairs across six independent trait comparisons after bootstrap re-sample tests of the average absolute difference of retinol, α-tocopherol and γ-tocopherol (μg/mL).

Vitamins	Maternal	Neonatal	N	Average absolute difference ± std err	P	Regression slope ± std err	P	R-square
Retinol	Plasma	plasma	48	0.09 ± 0.02	N.S.	0.22 ± 0.16	N.S.	0.26
	Milk	plasma	8	0.08 ± 0.01	N.S.	2.41 ± 0.78	*	0.62
α-tocopherol	Plasma	plasma	48	11.46 ± 0.96	N.S.	−0.10 ± 0.10	N.S.	0.13
	Milk	plasma	9	0.87 ± 0.27	N.S	0.18 ± 0.29	N.S.	0.05
γ-tocopherol	Plasma	plasma	48	1.19 ± 0.19	N.S.	0.04 ± 0.02	N.S.	0.45
	Milk	plasma	7	0.34 ± 0.07	N.S.	0.23 ± 0.06	*	0.75

N.S. means $P > 0.05$; $^{*}P < 0.05$.

Table 8. Pearson correlation coefficients for meconium minerals.

	K	Na	Ca	Mg	Mn	Zn	Cu	Co	Fe
K	1.00000	−0.12728 0.5355	0.67978 0.0001	0.72855 <0.0001	0.50154 0.0090	0.76048 <0.0001	0.62464 0.0006	0.10465 0.6794	0.77932 <0.0001
Na	−0.12728 0.5355	1.00000	−0.01240 0.9521	−0.24065 0.2363	−0.02288 0.9117	−0.19444 0.3412	−0.20170 0.3231	−0.15160 0.5482	−0.14592 0.4864
Ca	0.67978 0.0001	−0.01240 0.9521	1.00000	0.42693 0.0296	0.11704 0.5691	0.42715 0.0295	0.31727 0.1143	−0.14579 0.5638	0.46830 0.0182
Mg	0.72855 <0.0001	−0.24065 0.2363	0.42693 0.0296	1.00000	0.58022 0.0019	0.72037 <0.0001	0.66798 0.0002	0.11345 0.6540	0.83069 <0.0001
Mn	0.50154 0.0090	−0.02288 0.9117	0.11704 0.5691	0.58022 0.0019	1.00000	0.63754 0.0005	0.74219 <0.0001	0.03724 0.8834	0.55826 0.0037
Zn	0.76048 <0.0001	−0.19444 0.3412	0.42715 0.0295	0.72037 <0.0001	0.63754 0.0005	1.00000	0.77333 <0.0001	0.10715 0.6722	0.72294 <0.0001
Cu	0.62464 0.0006	−0.20170 0.3231	0.31727 0.1143	0.66798 0.0002	0.74219 <0.0001	0.77333 <0.0001	1.00000	−0.13288 0.5991	0.65012 0.0004
Co	0.10465 0.6794	−0.15160 0.5482	−0.14579 0.5638	0.11345 0.6540	0.03724 0.8834	0.10715 0.6722	−0.13288 0.5991	1.00000	−0.05306 0.8344
Fe	0.77932 <0.0001	−0.14592 0.4864	0.46830 0.0182	0.83069 <0.0001	0.55826 0.0037	0.72294 <0.0001	0.65012 0.0004	−0.05306 0.8344	1.00000

Among the investigated data there was a very close correlation between maternal and neonatal blood glucose levels (r = 0.70; P = 0.000); Urea (r = 0.992; P = 0.000) and Creatinine (r = 0.869; 0.000). However other parameters (BILT; BILD; BILI, ASTL) did not show any correlation in the plasma samples.

5. Conclusion

Most of the results obtained from the study data were in line with previous literature and indicated that maternal and neonatal health in the Van Basin is not at risk in terms of nutritional status.

Conflict of Interest

The authors declare no conflict of interest

Acknowledgements

The authors' work was supported by the University of Yüzüncü Yil, The head of Research Foundation coded as TF-B119.

References

[1] Krachler, M., Rossipal, E. and Micetic-Turk D. (1999) Trace Element Transfer from the Mother to the Newborn İnvestigations on Triplets of Colostrum, Maternal and Umblical Cord Sera. *European Journal of Clinical Nutrition*, **53**, 486-494. http://dx.doi.org/10.1038/sj.ejcn.1600781

[2] Okolo, S.N., Onwuanaku, C., Okonji, M., VanderJagt, D.J., Millson, M., Churchwell, C. and Glew, R.H. (2000) Concentration of Eight Trace Minerals in Milk and Sera of Mother-Infant Pairs in Northern Nigeria. *Journal of Tropical Pediatrics*, **46**, 160-162. http://dx.doi.org/10.1093/tropej/46.3.160

[3] Hanson, L.A. (1998) Biology of Human Milk, Nestle Nutrition Workshop Series. Raven Press, New York.

[4] Takada, M., Shimada, M., Hosono, S., Tauchi, M., Minato, M., Takahashi, S., Okuni, M. and Takeuchi, S. (1992) Trace Elements and Mineral Requirements for Very Low Birth Weight Infants in Rickets of Prematurity. *Early Human Development*, **29**, 333-338. http://dx.doi.org/10.1016/0378-3782(92)90188-M

[5] Viana, M., Barbas, C., Castro, M., Herrera, E. and Bonet, B. (1999) Alpha-Tocopherol Concentration in Fetal and Maternal Tissues of Pregnant Rats Supplemented with Alpha-Tocopherol. *Annals of Nutrition and Metabolism*, **43**, 107-112. http://dx.doi.org/10.1159/000012774

[6] Madem, M. (2000) The Pole of Retinoic Acid in Embryonic and Postembryonic Development. *Proceedings of the Nutrition Society*, **59**, 69-73.

[7] Turker, G., Ergen, K., Karakoç, Y., Arısoy, A.Y. and Barutcu, U.B. (2006) Concentration of Toxic Metals and Trace Elements in the Meconium of Newborns in an Industrial City. *Biology of the Neonate*, **89**, 244-250. http://dx.doi.org/10.1159/000089953

[8] Ölçücü, A. and Çağlar, P. (1993) The Zinc Levels in Human Hair and Blood Serum of Infants and Their Relationship to Various Diseases in the Upper Euprates Basin. *The Journal of Trace Elements in Experimental Medicine*, **6**, 141-145.

[9] Szymkiewicz, M.M., Niemiec, J. and Stepinska, M. (1990) Determination of the Relationship between the Contents of Mg, Zn, Cu, Fe and Mn in Blood and Feathers of Rhode Island Red Hens and the Results of Hatchability. *Annals of Warsaw Agricultural University SGGW-AR, Animal Science*, **25**, 8-14.

[10] Golamco, F.G., Harper, R.G., Sia, C., Spinazzola, R. and Wapnir, R.A. (2000) Mineral and Trace Elements in Meconium: Comparision in Dizygotic Twin Pairs. *Journal of Trace Elements in Experimental Medicine*, **13**, 205-213 http://dx.doi.org/10.1002/(SICI)1520-670X(2000)13:2<205::AID-JTRA4>3.0.CO;2-T

[11] Tolba, A., Hewedy, F., Al-Senaidy, A. and Al-Othman, A. (1998) Neonates' Vitamin A Status in Relation to Birth Weight, Gestational Age, and Sex. *Journal of Tropical Pediatrics*, **44**, 174-177. http://dx.doi.org/10.1093/tropej/44.3.174

[12] Agarwal, K., Dabke, A.T., Phuljhele, N.L. and Khandwal, O.P. (2008) Factors Affecting Serum Vitamin a Levels in Matched Maternal-Cord Pairs. *The Indian Journal of Pediatrics*, **5**, 443-446. http://dx.doi.org/10.1007/s12098-008-0070-1

[13] Baydas, G., Karatas, F., Gursu, M.F., Bozkurt, H.A., Ilhan, N. and Canatan, H. (2002) Antioxidant Vitamin Levels in Term and Preterm Infants and Their Relation to Maternal Vitamin Status. *Archives of Medical Research*, **33**, 276-280. http://dx.doi.org/10.1016/S0188-4409(02)00356-9

[14] Canfield, L.M., Giuliano, A.R. and Graver, E.J. (1995) Carotenoids, Retinoids, and Vitamin K in Human Milk. Handbook of Milk Composition, Chapter C, 693-704. http://dx.doi.org/10.1016/B978-012384430-9/50030-5

[15] Villard, L. and Bates, C.J. (1987) Effect of Vitamin A Supplementation on Plasma and Breast Milk Vitamin A Levels in Poorly Nourished Gambian Women. *Human Nutrition-Clinical Nutrition*, **41C**, 47-58.

[16] Awadallah, S.M., Abu-Elteen, K.H., Elkarmi, A.Z., Qaraein, S.H., Salem, N.M. and Mubarak, M.S. (2004) Maternal and Cord Blood Serum Levels of Zinc, Copper, and Iron in Healthy Jordanian Women. *Journal of Trace Elements in Experimental Medicine*, **17**, 1-8. http://dx.doi.org/10.1002/jtra.10032

[17] Yazbeck, C., Moreau, T., Sahuquillo, J., Takser, L. and Huel, G. (2006) Effect of Maternal Manganese Blood Levels on Erythrocyte Calcium-Pump Activity in Newborns. *Science of the Total Environment*, **354**, 28-34. http://dx.doi.org/10.1016/j.scitotenv.2004.12.012

[18] AMAP (2003) AMAP Assessment 2003: Human Health in the Arctic. Arctic Monitoring and Assessment Programme (AMAP), Oslo.

[19] Batler Walker, J.B., Houseman, J., Seddon, L., McMullen, E, Tofflemire, K., Mills, C. Corriveaue, A., Weberf, J.P., LeBlancf, A., Walkerg M., Donaldsong, S.G. and Oostdam, J.V. (2006) Maternal and Umbilical Cord Blood Levels of Mercury, Lead, Cadmium, and Essential Trace Elements in Arctic Canada. *Environmental Research*, **100**, 295-318. http://dx.doi.org/10.1016/j.envres.2005.05.006

[20] Rathi, S.S., Srinivas, M., Grover, J.K., Mitra, J.D., Vats, V. and Sharma, J.D. (1999) Zinc Levels in Women and Newborns. *Indian Journal of Pediatrics*, **66**, 681-684. http://dx.doi.org/10.1007/BF02726254

[21] Haram-Mourabet, S., Harper, R.G. and Wapniri, R.A. (1998) Mineral Composition of Meconium: Effect of Prematurity. *The Journal of the American College of Nutrition*, **17**, 356-360. http://dx.doi.org/10.1080/07315724.1998.10718775

[22] Türker, G., Ergen, K., Karakoç, Y., Engin Arisoy, A. and Barutcu, U.B. (2006) Concentrations of Toxic Metals and Trace Elements in the Meconium of Newborns from an Industrial City. *Biology of the Neonate*, **89**, 244-250. http://dx.doi.org/10.1159/000089953

[23] Gonzales de Dios, J., Benovent, M.N. and Cortes Castell, E. (1996) Cuantifi Cacion de la Excrecion Fecal de Elementos Traza en Recien Nacidos como Expresion de la Secrecion Intestinal Fetal. *Anales de Pediatría*, **45**, 281-285.